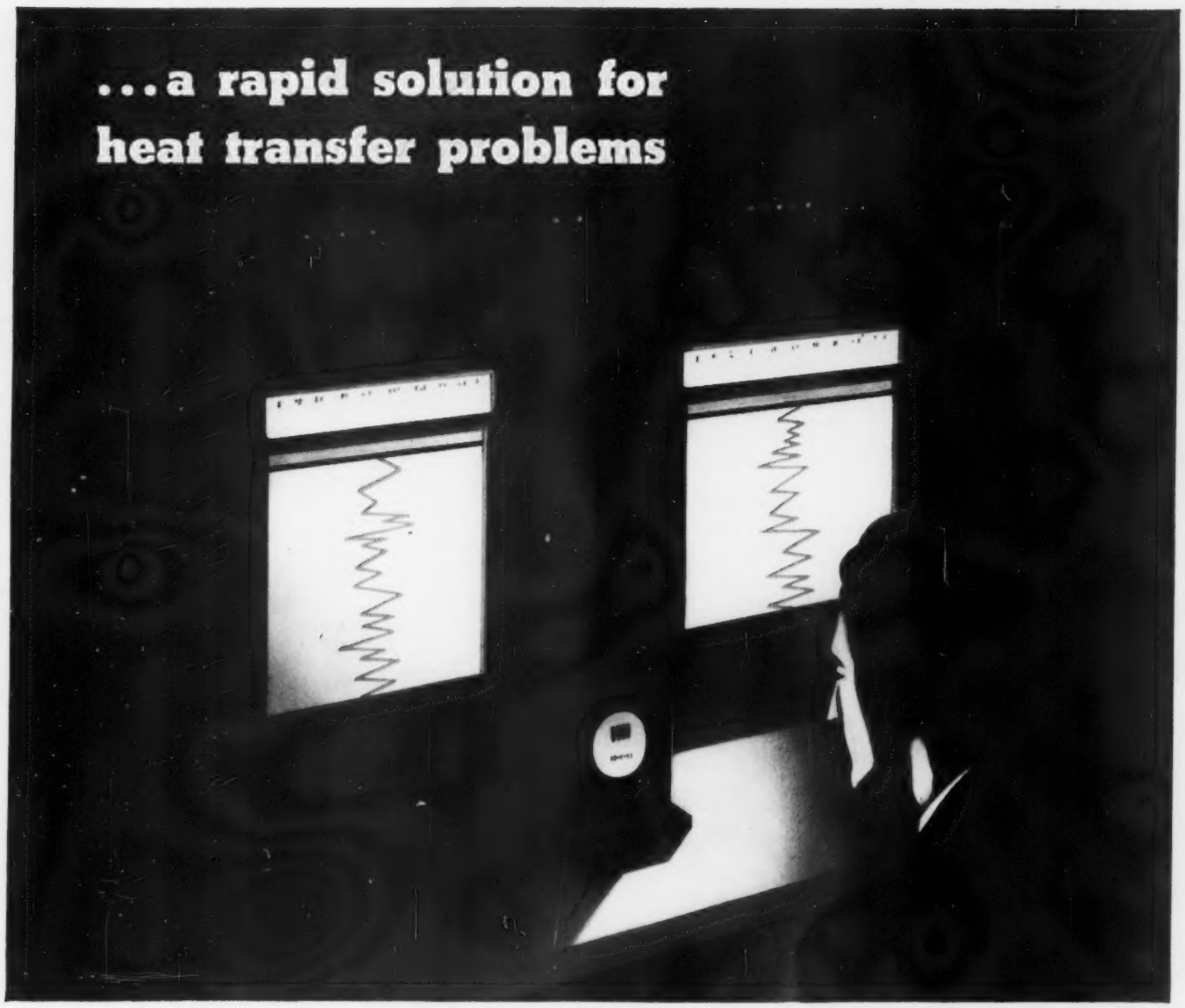
TECH ENGINEERING NEWS

OCTOBER · 1942

...a rapid solution for heat transfer problems



Information supplied by "Mechanical Engineering"

Dr. Victor Paschkis, of Columbia University, has developed a rapid, inexpensive, and highly accurate method for the solution of heat-transfer problems.

Operation is based on the proved mathematical similarity of certain thermal and electrical phenomena. The method is accurate because easily made and recorded electrical measurements are substituted for difficult and erratic thermal measurements. When the temperature and thermal characteristics of substances are known, solutions are quickly obtained. But the method is also applicable to substances whose thermal characteristics are unknown.

Such diverse problems as heat loss in building materials, determining the time-temperature gradients in turbine rotors, or the thermal characteristics of plastics, are quickly and accurately solved.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
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MOLY

Gilbert D. McCann, Ph.D., M.S.
...Master of Thunderbolts, too!

MODERN FARADAY CAGE. Three million volts of man-made lightning hit a car in Westinghouse High Voltage Laboratories, while Dr. Gilbert D. McCann sits safely at the wheel. Dr. McCann . . . co-inventor of the "fulchronograph" for timing and measuring the intensity of thunderbolts . . . joined Westinghouse in 1939, after receiving degrees of M.S. and Ph.D. at the California Institute of Technology.

EVERY TIME you take a breath, 175 thunderbolts crash to earth somewhere.

These lightning strokes, streaking down at 600 million miles an hour, are charged with torrents of electrical power . . . as much as 200,000 amperes, at pressures as high as 25,000,000 volts.

No wonder protection against lightning has been a major problem to utility companies . . . such a problem that, up to a few years ago, lightning frequently shut down power service to industry.

Today, a properly designed power line is not likely to be put out of service by lightning *more than once in 5 or 10 years!*

Dr. Gilbert D. McCann and Charles F. Wagner, Westinghouse engineers, have done much to make this possible through their studies of natural thunderbolts and laboratory lightning.

One of their contributions is the "fulchronograph" which automatically times natural lightning strokes and measures their intensity. Oscillographs and movie cameras also are used to photograph the celestial fireworks.

These mechanical "eyes" . . . perched high on the top of scores of tall buildings, smoke stacks, and transmission-line towers . . . are constantly collecting facts about lightning phenomena that were never known before. Facts about "cold" lightning, of terrific blasting power. Facts about "hot" lightning, the incendiary bomb of the sky.

Still further knowledge is gained from the study of *artificial lightning* . . . made in the Westinghouse High Voltage Laboratories. This man-made lightning is used to bombard insulators, lightning arresters, and other protective devices to test their efficiency.

These studies are constantly adding to the store of "know how" in the field of power transmission. As a result, Westinghouse engineers have been able to design and build lightning arresters and ground-wire systems that tame the wildest thunderbolt.

The work done by Dr. McCann is contributing mightily to America's war effort by helping to keep electric power flowing night and day to our vast war industries . . . as well as by protecting ordnance plants from destruction by lightning.

America needs scientists and engineers as never before . . . to help solve the technical problems of modern warfare and to rebuild the world when the last shot is fired.

Nearly 300 young engineering graduates joined Westinghouse last Spring to carry on this work. In the Class of '43 there will be many graduates who will have an equal chance to help win the war . . . and the peace to come . . . with Westinghouse.

Westinghouse

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURGH, PENNSYLVANIA • PLANTS IN 25 CITIES — OFFICES EVERYWHERE

While Victory is being won prepare for the work of peace. Learn to know your bearings.

TO ASSURE VICTORY
BUY UNITED STATES WAR SAVINGS BONDS & STAMPS

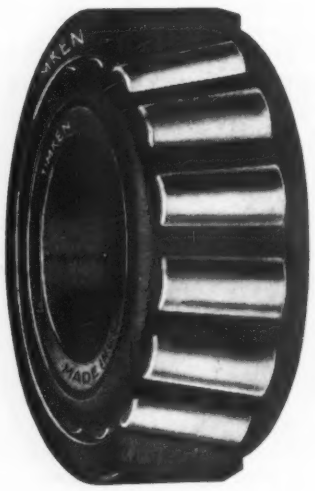
American planes, tanks, trucks, guns and warships are doing an outstanding job in the fight for freedom because, in addition to being good all-around engineers, their designers *know their bearings.*

After Victory, when we have made sure that the things our forefathers fought and died for shall not perish from the earth, *"knowing your bearings"* will be one of the most important assets you or any young engineer can possess.

For when the tremendous work of reconstruction starts, machines of all kinds will be required to have higher speeds, greater precision and endurance and be more economical to operate and maintain than ever before.

In achieving these objectives, Timken Tapered Roller Bearings will be used to an even greater extent than in the past because of their ability to meet—and beat—any and every bearing condition that might develop.

Now is the time to learn to know your *Timken Bearings.* Our engineers will be glad to help you.



THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

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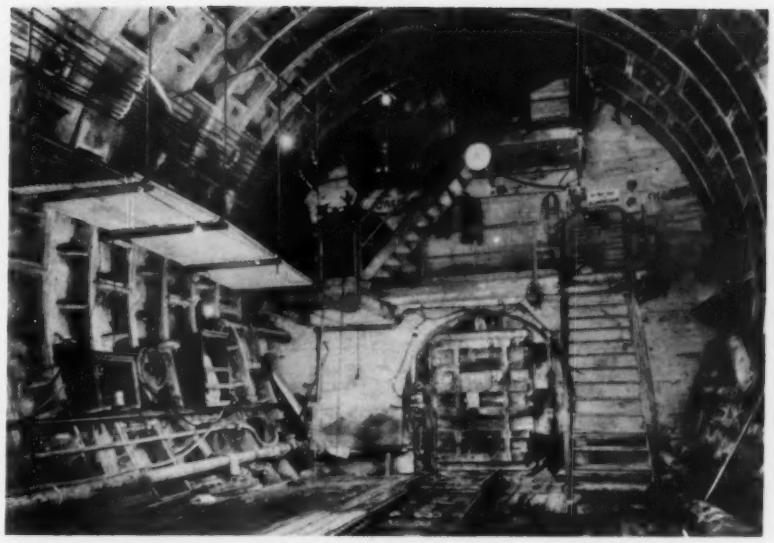

New York City Tunnel Authority

Queens Midtown Tunnel; compressed air side of tunnel bulkhead, showing muck lock at bottom, manlocks at intermediate height and reduced size and emergency lock at top. See page 104.

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FRANKLY SPEAKING

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MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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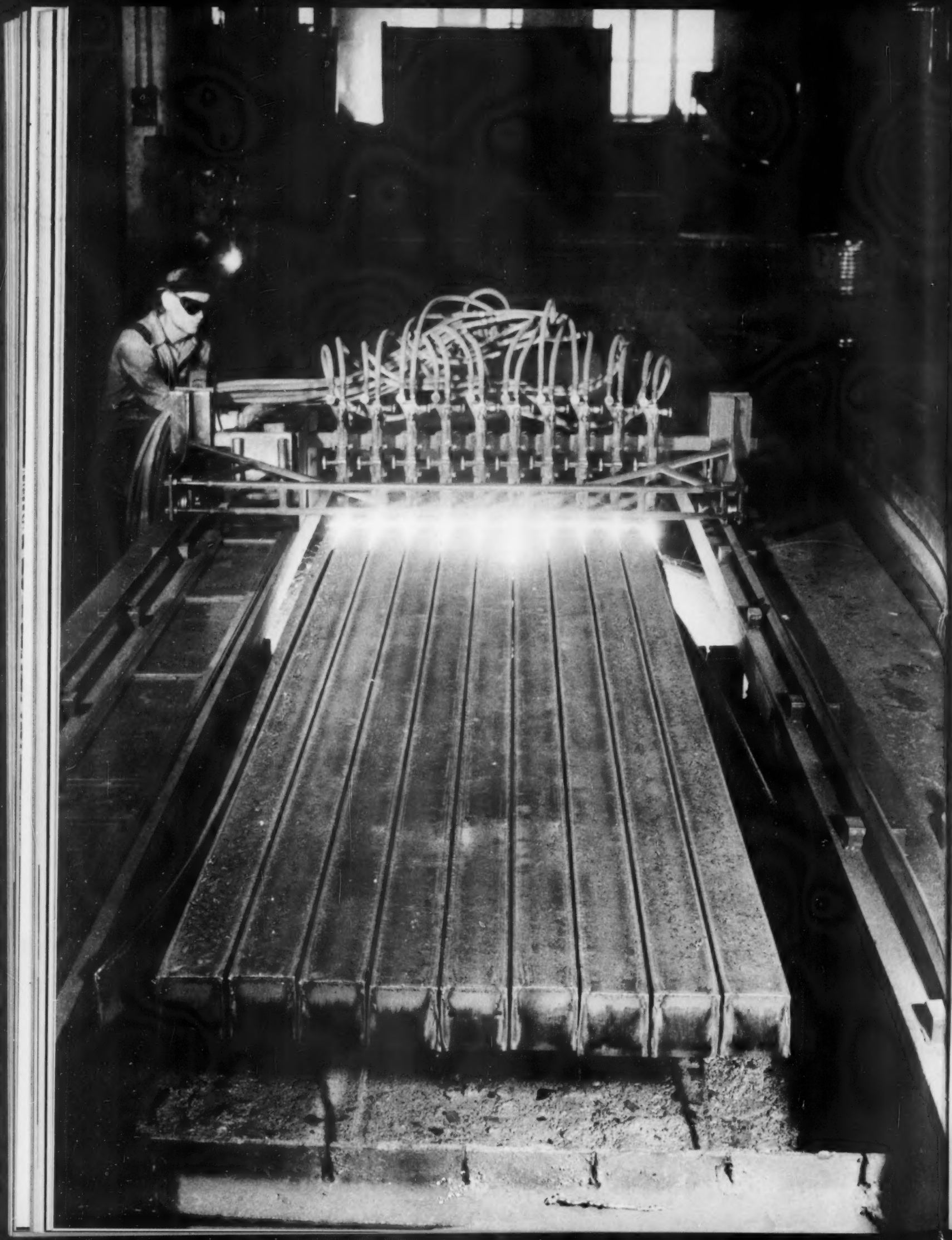


Oxyg
Air Re

CARVING STEEL WITH OXYGEN

HOW A SLENDER JET OF OXYGEN CUTS AND SHAPES STEEL IN OUR WAR INDUSTRIES

By FORREST WALDO

APPLIED ENGINEERING DEPARTMENT, AIR REDUCTION SALES COMPANY

LIKE many other combustible elements, the tendency of iron to oxidize is so vastly increased at elevated temperatures that when iron at 1600° F. is brought into contact with pure oxygen the chemical reaction is almost instantaneous. In an oxygen atmosphere, iron which has been brought to its ignition temperature burns freely, liberating sufficient heat of combustion to sustain the reaction.

The process of cutting steel with a jet of oxygen is simply a controlled application of this rapid oxidation. The oxygen cutting torch provides within itself both of the necessary conditions for localized burning or oxidation of iron; a small circle of oxyacetylene flames preheats a small area to kindling temperature, followed by a central jet of pure oxygen which burns its way through the metal. As the stream of cutting oxygen penetrates the steel, the torch is moved slowly across the surface of the metal, leaving in its wake a narrow slot or kerf. Cutting machines, some of them quite elaborate, carry one or more torches automatically over the surface of the steel, making smooth, perpendicular cuts of high quality. By this means a thick steel plate can be readily cut into vari-shaped patterns, much like a baker cuts cookies out of a slab of rolled dough. And in fact, in the jargon of the cutting operator the resulting steel shapes are called "cookies."

Keeping in mind the fact that this rapid oxidation takes place only when the metal is red-hot, it may be in order to show how the oxygen stream can penetrate many inches when only the top surface of the steel is preheated by the oxyacetylene flames. In starting a piercing cut the oxygen jet is released perpendicular to the preheated spot on the surface, and as the surface metal burns, its heat of combustion preheats the adjacent metal to kindling temperature. The constant flow and the direction of the oxygen stream maintains combustion in a downward direction, so that it is progressive and self-sustaining. As the full-penetration cut is carried along, roughly two-thirds of the metal is oxidized, liberating heat for continuation of combustion. The remaining third is swept out by the high-velocity jet as molten iron. Since the heat of combustion is carried by conduction into the metal ahead of the direction of torch travel, the metal at all depths is thereby preheated and burns when the movement of the torch brings oxygen into contact with the hot metal.

Theoretically, 4.6 cubic feet of oxygen will oxidize one pound of iron to Fe_3O_4, but because part of the iron along the line of cut is blown out as molten metal, the amount of pure oxygen which must be provided is usually less than the theoretical requirement.

Flame cutting has revolutionized the metal forming and fabrication industries. Its jigsaw flexibility, its capacity to cut steel up to forty inches or more in thickness, its economy and the portability of the required apparatus, coupled with numerous other advantages, have established the process as one of the major tools of industry. Prior to its advent in 1907, metals could be shaped only by sawing, planing, milling, turning, or by shearing of plates under two inches in thickness. Only the larger shops could afford the heavy investment in equipment required. The alternate method of producing involved shapes was by casting.

While neither of these basic methods of forming metals has been, or will be displaced by the fabrication industry which has grown up around the oxygen cutting process, it serves both as a supplementary tool to the traditional methods and as a basic fabrication process in itself. The widespread adoption of welding as a construction method is founded largely on the ability of flame cutting machines to provide a steady flow of shape-cut parts for welded assembly. In many cases one-piece shapes may be put to their intended use without finish machining, just as forgings are often used. Where the working surfaces and dimensions of the finished part must meet close tolerances, oxygen cutting takes the place of rough machining to remove large quantities of excess metal and turn out a shaped part which is then finish machined on the critical surfaces. The castings industry uses the torch to remove risers and pouring gates, cutting them off close to the surface so that only a light grinding operation is needed to smooth off the casting.

Today, the flame cutting torch is an indispensable tool in our nation's shipyards, tank arsenals and innumerable other war production industries. Almost without exception, every piece of ship side plating, bulkhead and floor plates and structural shapes are cut to proper shape on gas cutting machines. Sprocket wheels and

Oxygen torches in an emergency role
Air Reduction Sales Co., 60 East 42d Street, New York

armor plate for the new M-4 and other tanks and motorized equipment are likewise speedily cut from standard plate thicknesses. With modern flame cutting machines, eight or even ten torches can cut as many identical shapes or "cookies" simultaneously, being guided by a magnetic tracing device which automatically follows the contour of a steel template. Sometimes a number of thin plates are clamped together and cut as a single thick piece, and occasionally this stack cutting process is done with torches in multiple to produce an even greater number of identical shapes in a single operation.

Unlike most metal working machines which form the steel with brute force, the oxygen cutting machines are fractional-power devices, since their only function is to carry the torch or torches accurately and at constant speed over the prescribed course. As has been said, this course may involve any pattern or shape within the span of the machine, the variety of contour being limitless. Cutting speeds vary from twenty inches per minute for one-quarter inch steel, to three inches per minute on twelve inch thick material. The width of the cut or kerf varies from five sixty-fourths to one-quarter inch between these thicknesses.

Plainly, if the oxygen jet were able to do no more than serve as a cutting tool, its usefulness to industry would still be enormous. But it serves other functions as well, and indeed there is hardly a stage in the manufacture of steel from blast furnace to rolled plate where the oxygen torch does not come into play.

Tapping of the blast furnace is done with an oxygen lance, piercing a hole which releases the molten iron to flow out into pig molds. In the raw billet or slab form, defects such as scabs and seams are "washed out" with the hand scarfing torch. This operation might be loosely described as tangential cutting, using a wide-orifice torch tip and a low-velocity jet to remove surface metal without penetrating too deeply. Scarfing torches are sometimes used in multiple for skinning off the entire surface of a slab in a single pass, preparing it for final rolling.

In another way, torches employing oxygen for surface shaping of steel are handy assets to the welder. When joining heavy plates the weld metal is deposited in a V- or U-shaped channel running the length of the abutting plate edges. Specifications for high quality joints require that after making this weld, the root of the running V be gouged out from the back and re-welded. For this operation a gouging torch removes the weld root at unbelievable speed, plowing a clean furrow by burning away the steel. In the same way old welds are gouged out in dismantling operations, far more quickly than could be done with a mechanical chipping tool. Defective areas in completed welds, revealed by the X-ray, are commonly routed out with the torch and the groove refilled with sound weld metal.

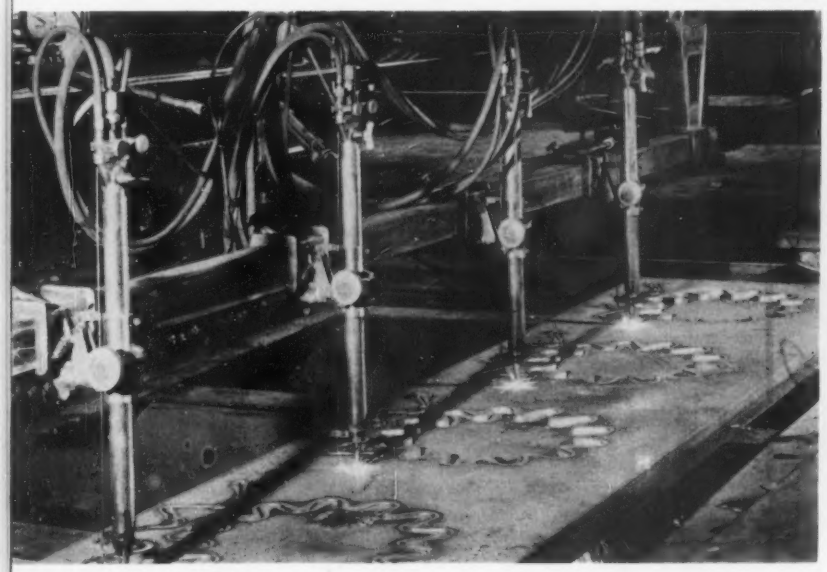
It is evident from the foregoing that the oxygen jet is a tool of extreme flexibility in sculptoring steel. As a strictly cutting tool it has reached a high stage of development, and further advances in this direction will be chiefly in extending the scope and versatility of the machines and the torches. It is in the broad field of flame machining, however, that many developments remain to be made. The aforementioned scarfing, lancing, skinning and gouging are only a few of the operations falling under this heading. Another which has passed from the pioneering stage to widespread use as a standard production practice is the grooving of plate edges preparatory to welding. By proper arrangement of one or two torches on a straight-line cutting machine, the edge of a plate may be "machined" with a diagonal, J, or double-J shaped edge. These grooves are made to astonishingly close dimensional tolerances, and have a perfectly smooth, non-rippled surface. This is an operation which was formerly a task for giant planers, and the fact that the flame has been able to take over much of this work is now of inestimable value to shipyards and other war production industries.

Still in the pioneering stage, however, are other flame machining processes having enormous potentialities. Merely to list them is sufficient to indicate the possibilities of this field. They are: planing, milling, turning, drilling and boring. These are quite general headings, as is evident from the fact that skinning is a planing operation, plate edge grooving is a milling process, and lancing is a variation of drilling.

Taking, as an example, a brief glimpse into the experimental work already done on flame turning, we will see how effectively this process may be used in the future to supplement the work of machine tools in sculptoring steel. Spiral threads have frequently been

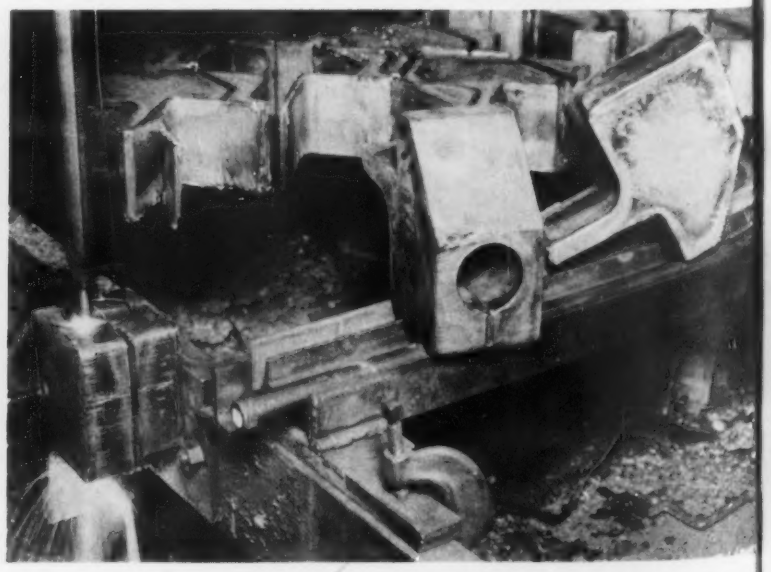
Guided by a magnetic tracer following the contour of a steel cam, four oxygen cutting torches cut four Army tank sprockets from steel plate.

Air Reduction Sales Co.



Versatility of torches and cutting machines is shown by the cutting of a slot and circle in brackets previously flame cut in multiple from seven-inch steel plate.

Air Reduction Sales Co.



Air Reduction Sales Company

Thickness offers no obstacle to the cutting jet

cut on cylindrical shafts, at speeds far in excess of comparable machine tool cutting. A typical turning operation would be one of cutting down a section of four-inch diameter round stock to say two inches in diameter. Such a cut is made with the torch mounted on the lathe cross-feed carriage, making first a milling cut one inch deep, and then moving the torch carriage steadily across as the shaft rotates. Thus the entire one-inch deep cut is made in a single pass of the torch.

Now, since any machining operation is essentially a matter of removing metal, let us compare the rate of metal removal by the oxygen cutting jet with that of high speed machine tools. In the turning operation just described, measurements have shown that plain low carbon steel is oxidized away at twenty to thirty pounds per minute. A high speed steel cutting tool, taking a cut three-eighths inch in depth, would remove such steel at about ten to twelve pounds per minute. The difference here is only about two to one, but if the steel were of a higher hardness analysis the rate of removal by machine tool drops to two or three pounds per minute, whereas the exact contrary occurs with the torch. Harder steels respond more readily to oxidation than the low carbon steels. The comparative rate under these conditions would be a minimum of ten to one in favor of oxygen cutting. In some operations the torch cuts fifty times as fast as a machine tool.

While it may appear at first glance that a tangential cut made with such a non-precision tool as a jet of oxygen would be rough and irregular, the actual results are far more encouraging. From the standpoints of both smoothness and dimensional regularity the cuts are of very high quality, and certainly equal to those obtained by rough machining. Tolerances of one-sixteenth inch are usually met, and for a good many purposes the flame machined part could be installed in service as cut. Where precision tolerances are required, finish machining would of course be necessary.

Thus the outlook for flame machining as a super-high speed process of metal removal on production operations is uncommonly bright. Each application offers a problem in itself, but the number of successful operations already developed experimentally indicates that it is a fruitful field for exploration, and one that will undoubtedly progress rapidly in the post-war industrial evolution.

So far we have discussed only the technical aspect of oxygen cutting, from the viewpoint of the metallurgist and the production engineer. Now let us see how it affects the designer and the final fabricated product.

Flame cutting is usually, though not always, a companion process to welding. Flame-cut parts are often used in riveted or mechanically joined assemblies, but the greater part of the ever-growing use of flame cutting is linked to the phenomenal growth of welding as a standard production process. Industry has begun to adopt welded fabrication for a number of very specific reasons.

First and foremost, a properly welded joint is almost invariably stronger at the weld than in the parent metal. This being true, the designer utilizing rolled steel sections may eliminate all joint-strengthening devices which are necessary in other methods of construction. Thus, special brackets, flanges and reinforcing plates are dispensed with. For the same reason he may specify somewhat thinner plate sections for the structure, since he need not add extra weight to compensate for the weakening effect of rivet or bolt holes. Overlapping of plates for riveting is also eliminated, resulting in further weight reduction and a smoother contour, since joints are butt welded. All of the foregoing add up to a saving on most welded assemblies of fifteen to thirty per cent in steel requirements, a figure which would be important in any day but doubly so today, when steel is precious.

And so it goes. Welding, once regarded suspiciously as a repairman's subterfuge, is now a ranking production process. Fully twenty-five per cent of the ships now being built are all-welded vessels, saving twenty per cent of the steel needed for victory, and carrying twenty per cent more cargo to the bastions of democracy. The patterns for each piece of ship plate are laid out in the mold loft and traced directly on steel with a machine-guided oxygen torch. In the tank arsenals, heavy armor plate for the welded M-4 is likewise cut to shape and the edges beveled for welding. Throughout war production industries generally these companion processes are indispensable for the making, shaping and fabrication of the tools of mechanized warfare, and on the fields of battle they are used in mobile repair stations to help restore damaged weapons to fighting condition.

Torch, cutting a deep spiral thread

Air Reduction Sales Company

TRAFFIC GOES UNDER

MAMMOTH UNDER-RIVER TUNNELS HELP SOLVE NEW YORK CITY'S TRAFFIC PROBLEM

By OLE SINGSTAD

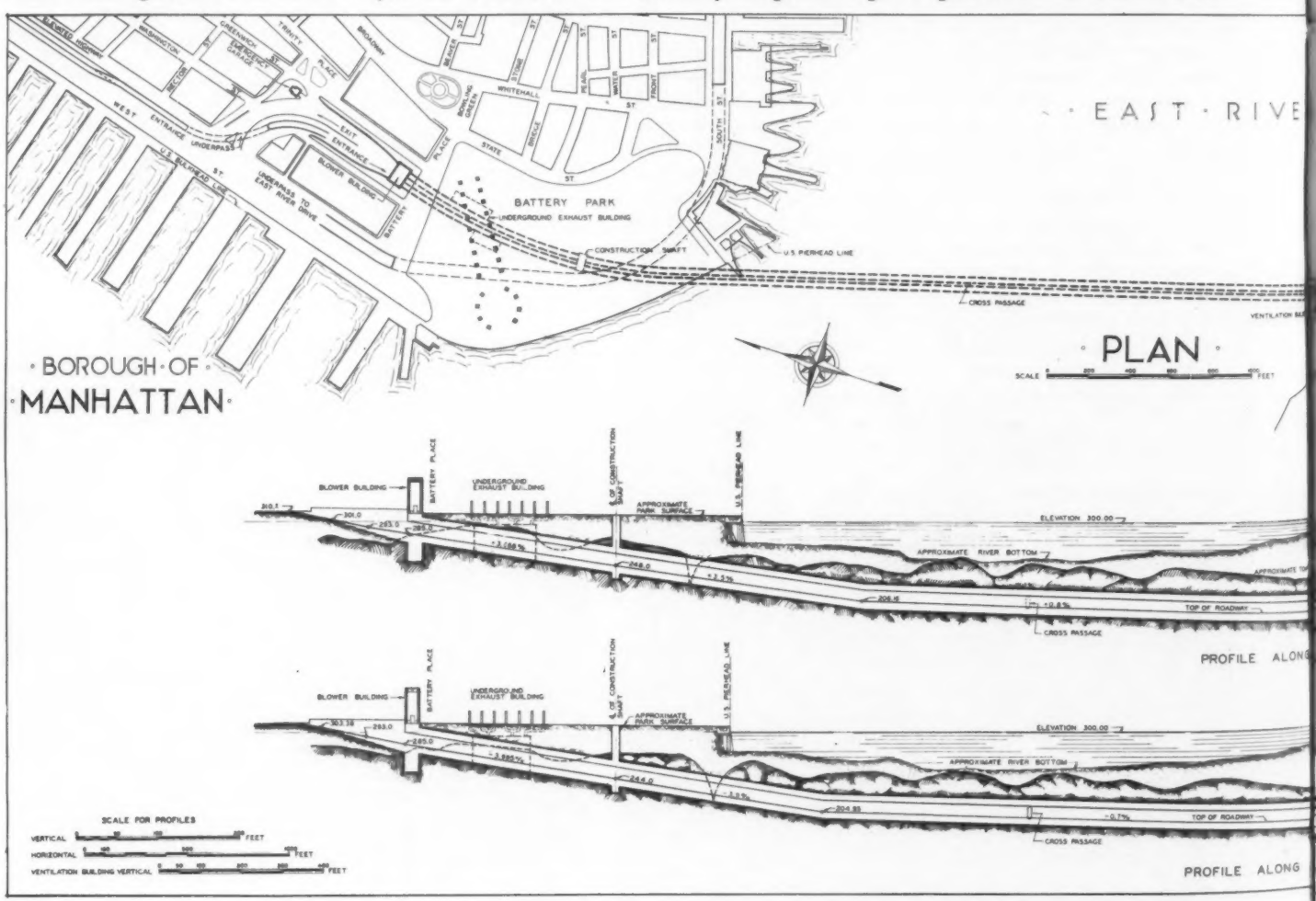
CHIEF ENGINEER,
NEW YORK CITY TUNNEL AUTHORITY

THE New York City Tunnel Authority is a public benefit corporation of the State of New York, authorized to construct and operate certain vehicular tunnel projects within New York City as self-supporting and self-liquidating enterprises. Its program includes the Queens Midtown Tunnel, regular operation of which was begun on November 15, 1940; the Brooklyn-Battery Tunnel, now under construction; the Narrows Tunnel, for which preliminary studies, estimates and investigations are under way; and the Midtown Manhattan Underpass, for which the City of New York has recently authorized funds for studies of route. All of the four projects enumerated form important links in the comprehensive scheme of vehicular traffic arteries in the New York Metropolitan area. Their locations and principal highway connections, existing and proposed, are shown on the accompanying map.

The Queens Midtown Tunnel, which is approximately 7,600 feet long from street grade to street grade on plazas, forms the East River express link in an important route along the east-west axis of the New York Metropolitan area. To complete this route so that it is entirely express from the parkways and boulevards of Long Island to West Side Manhattan and the New Jersey mainland, the construction of the Midtown Manhattan Underpass, joining the Queens Midtown and Lincoln Tunnels, is necessary; the Midtown Highway, the principal tunnel connection in Queens, also remains to be completed by the City to Horace Harding and Woodhaven Boulevards.

The Brooklyn-Battery Tunnel, which will be about 11,100 feet long between street grade points on plazas, will form the East River express link joining important routes from South Brooklyn, Bay Ridge and Flatbush in Brooklyn with the two main north and south express arteries of Manhattan, Miller Highway and East River Drive. Gowanus Parkway, which connects directly with the Brooklyn-Battery Tunnel, will provide the Narrows Tunnel, to be constructed between Richmond and Brooklyn, with an express outlet to Manhattan.

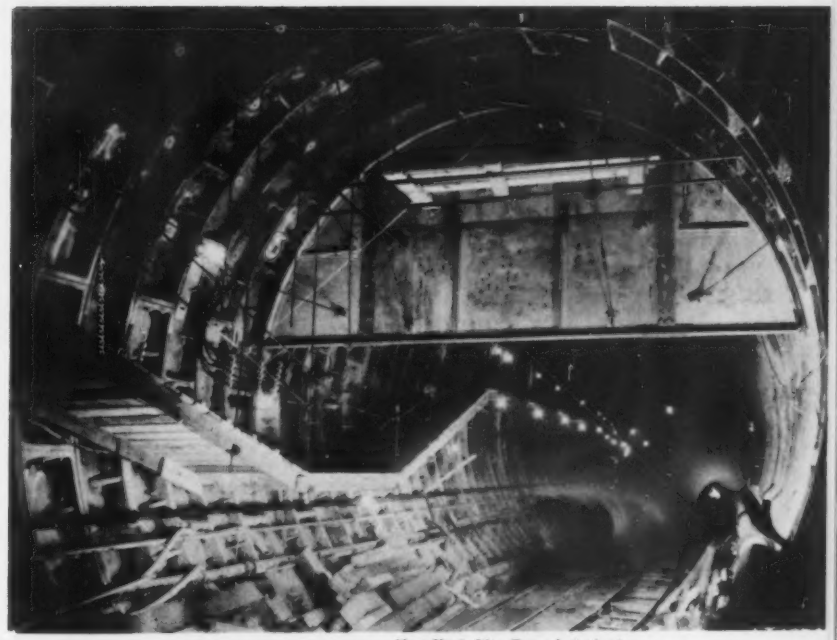
These tunnels have been recognized for many years as essential factors in the development and modernization of traffic routes and facilities in New York City, and as necessary in order to provide adequately for the normally large and growing volume of automotive



traffic, which moves in and out of the City and between boroughs.

The Queens Midtown Tunnel, which has an estimated maximum capacity of 16,000,000 vehicles per year, provides two tubes, each with a roadway two traffic lanes wide, and cost approximately $54,250,000 to build, about $6,800,000 of this amount being for real estate; construction contracts amounted to $38,900,000 and the remainder of the cost covered engineering, administration, interest during construction, operating equipment and miscellaneous expenses. Ground was broken for the project on October 2, 1936 by President Roosevelt and the tunnel was placed in operation on November 15, 1940 after a construction period of approximately four years. Ground was broken for the Brooklyn-Battery Tunnel on October 28, 1940 by President Roosevelt just before the Queens Midtown Tunnel started operations. The number of tubes and capacity are the same as for the Queens Midtown Tunnel. The plaza to plaza cost of this project is estimated to be $57,000,000, exclusive of real estate, about $49,000,000 being the estimated cost of construction contracts.

With the construction of the Queens Midtown Tunnel, the Tunnel Authority inaugurated a program of providing New York City with several highway tunnels, construction of which had long been delayed on account of the relatively high costs involved; this it is doing without imposing any burden of taxes or liability for costs upon either the State or the City governments. The three commissioners of the Authority, Alfred B. Jones, Chairman, Albert T. Johnston and William H. Friedman, who serve without compensation, obtained the financing of the Queens Midtown Tunnel through the Public Works Administration, which made available $58,365,000, the estimated cost,



New York City Tunnel Authority

Queens Midtown Tunnel under construction

$11,235,000 as a grant and the remainder as a loan on a four per cent, forty-year basis, to be secured by revenues from tolls. The actual cost of constructing the tunnel was $4,000,000 less than the total amount which had been allocated to the project. The Reconstruction Finance Corporation is loaning $57,000,000 on a three and a half per cent, fifty-year basis, similarly secured by revenues from tolls, to the Tunnel Authority for

New York City Tunnel Authority

Rear view of fully equipped shield as tunneling started at Manhattan

the construction of the Brooklyn - Battery Tunnel.

Both the Queens Midtown Tunnel and the Brooklyn-Battery Tunnel are designed on the pattern of the Holland Tunnel, the first modern tunnel to be constructed for the use of automotive vehicles.

As in the case of the Holland Tunnel the circular section has been used as best adapted to the shield and compressed air method of construction, which is necessary under the conditions encountered in the Hudson and East Rivers. The circular section also permits a simple and economical design of the lining and provides efficiently for the air duct areas and roadway widths and clearances required. The primary lining for the river crossings is the typical cast iron lining which is almost universally used in shield driven tunnels. The outside diameter is 31 feet, and the tubes are formed of a series of rings, each 32 inches long, made up of 14 circular segments and a key. The 32-inch length of ring was first used for the lining of the Queens Midtown Tunnel, and constitutes a two-inch increase over the maximum ring length used in the river tunnels around New York up to that time. The increase in ring length cuts down the amount of bolts, caulked joint and shield shoving operations necessary for a given length of tunnel. The cast iron lining used for tubes constructed in earth and earth and rock has 14-inch flanges and is bolted together with 1¾-inch diameter high tensile steel bolts; the individual segments weigh 1.5 tons each and the 32-inch ring 22.7 tons. A lighter weight cast iron lining is used in full rock sections; this lining has 11-inch flanges and is bolted together with 1¼-inch diameter high tensile steel bolts; a full ring weighs

Tightening bolts at upper part of lining of Queens Midtown Tunnel

New York City Tunnel Authority

12.5 tons.

The contact faces of the flanges of the lining are accurately machined to provide for a close fit in erection. Rebates at the edges of the flanges form grooves $\frac{3}{8}$ inch wide and $1\frac{1}{4}$ inch deep when in contact, which are caulked to provide watertightness.

Besides the light cast iron lining used in the shield driven rock sections of the Queens Midtown Tunnel, welded structural steel tunnel lining was used in the rock tunnels in the Manhattan land section. Here the tubes were 32 feet 10 inches in outside diameter to allow for roadway widening on curves. The choice of structural steel lining was based on competitive bidding with cast iron lining, which was included as an alternate in the contract for this section. In the bidding for the rock tunnel section under the river for the Brooklyn-Battery Tunnel, the low bid was made and awarded on the basis of cast iron tunnel lining.

For short lengths near the portals, the Queens Midtown Tunnel is constructed in open cut with steel bent and concrete structures. Similar construction will be used at the sections adjacent to portals for the Brooklyn-Battery Tunnel; on the Manhattan side, reinforced concrete construction will also be used.

The open approaches or plazas of both projects are constructed with reinforced concrete retaining walls faced with seam face granite; reinforced concrete invert slabs also serve as paving base. Slabs up to eight feet thick are used in the plazas of the Queens Midtown Tunnel, which are designed of sufficient weight to counterbalance hydrostatic uplift. The Brooklyn plaza of the Brooklyn-Battery (*Continued on page 116*)

New York City Tunnel Authority

Compressed air and hydraulic equipment used in constructing Queens Midtown Tunnel, Queens side

Finished interior, Queens Midtown Tunnel

New York City Tunnel Authority

HARDNESS—
ONLY SKIN DEEP

KEEPING MODERN TOOLS FIT BY HARD SURFACING WITH WEAR-RESISTANT ALLOYS

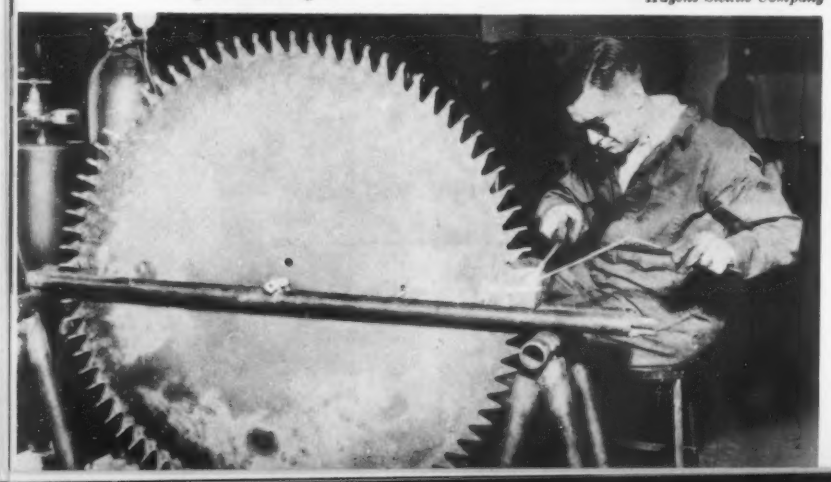
By HAYNES STELLITE COMPANY

AN important problem facing many engineers is that of preventing undue wear of machine parts. Although an enormous number of excellent lubricating oils and greases, special anti-friction bearings, dry lubricants and other materials affording a low coefficient of friction have been developed, oftentimes the details of the manufacturing process or conditions of service preclude their use. It would be impossible, for instance, to lubricate tools in contact with and handling abrasive materials such as rock, ore, sand or clay. In such cases, it is necessary to make the wearing part or surfaces as hard and wear-resistant as possible. Because of this, to take three typical examples, special steels find wide use in such severely treated parts as dipper buckets and railway frogs and cross-overs, wear-resistant bronzes are employed to screen coal, and hard diamond substitutes are used to protect the cutting edges of oil well drilling bits.

A recent development in this battle against friction is the practice of coating wearing surfaces with a material especially designed to withstand rough usage and abrasion. One of the most effective of such facings is an alloy of cobalt, chromium and tungsten welded on to the surface of the part to be protected. The process for doing this is known as "hard-facing." The wear-resistant metal is applied to the surface to be covered either by the oxy-acetylene flame or, less frequently, by the electric arc. After cooling from the welding heat, the hard-faced surface is ground to shape, if necessary, and the part is then ready for use. Parts protected in this manner last from three to seven times longer than the hardest steel.

Applying hard-facing material to the teeth of a rotary saw for cutting slate

Haynes Stellite Company



The history of the development of this hard-facing alloy is interesting. The late Elwood Haynes, one of the pioneers in the automotive industry, was responsible for its discovery and development. Searching for a stainless metal from which to make tableware and cutlery, he found several alloys of cobalt and chromium which were non-tarnishing, silvery and, on the whole, quite suitable. Later, upon the addition of tungsten to this alloy, the material became so hard that no ordinary tool steel could cut it. Discovering this fact, Haynes decided that the metal might be usable as a cutting tool material in his automobile plant. It worked splendidly. During World War I, when production of machine parts was at its peak, Haynes Stellite alloy, as the metal was named, was an invaluable aid. Cutting at higher speeds, it increased production far above the levels possible to obtain with ordinary tool steels. Its use has since become so widespread that now it is employed in machining operations throughout the manufacturing world.

In 1920, the process of applying this hard alloy as an abrasion-resistant coating on other metals was perfected. Hard-facing was immediately adopted by the cement manufacturing industry. In 1924, the hard-facing alloy was first introduced for protecting the cutting and reaming edges of rotary oil well drilling bits. Although drilling tools are subjected to terrific abrasive action, the hard-faced edges proved their economy by more than doubling their former life. Although oil well bits are now hard-faced with the even more wear-resistant tungsten carbide diamond substitutes, the cobalt-chromium-tungsten alloy is the standard hard-facing material wherever surface smoothness combined with extreme abrasion-resistance is a requirement.

The wide scope of the hard-facing process is readily apparent when it is considered that wearing surfaces ranging all the way from brick-making machine parts to aircraft engine valves are now successfully hard-faced. Hard-faced plowshares turn over five times the acreage of ordinary shares. Punches used for hot-punching holes in steel plate one inch thick, lasted an average of but 800 holes in an Indiana steel plant. Hard-faced, these punches are still as good as new after punching 1,600 holes. On the *S.S. Queen of Bermuda*, the whistle is operated by a hard-faced valve. Prior to hard-facing,

Haynes Stellite Company

Hard-facing the teeth of rotating caisson cylinder

the valve used to leak after three days and fail in two weeks. After the valve was hard-faced, the *Queen* whistled trouble-free for over six months.

In hydro-electric plants using very high heads of water as their source of power, the directing nozzles and needles have to be extremely accurate so that peak efficiency of the turbines may be maintained. At one such installation in California, the water, under a head of 2,200 feet, travels at a rate of over 400 miles per hour through the nozzle. It is only natural that bronze needles should be severely eroded in a short time. They had to be repaired in eight weeks and were badly worn in two to three years. Hard-faced steel needles have now been in service for over six years and are still in good condition.

Wherever the abrasive action of stone or clay is encountered, as in mining, excavating, and dredging, machine parts such as coal undercutter bits, dipper bucket teeth, dredging cutter blades, and bucket lips can be protected by a wear-resistant alloy.

If the abrasion is intensified by heat, as in the iron and steel and the coke and gas industries, hard-facing proves doubly valuable. Water-cooled clinker pokers, hot-shearing knives, hot-trimming dies, rolling mill guides, and furnace tap hole augers are but a few typical parts whose life and efficiency are both increased by this protection.

Production in both the cement and brick-making industries is increased when wearing parts are hard-faced. In fact in every shop where machine parts must be replaced frequently — and but few escape — hard-facing results in substantial economies.

Probably the most outstanding characteristic of the hard-facing alloys of cobalt, chromium and tungsten is their property of red hardness; that is, hardness at high temperatures. Most tool steels possess it to a reasonable degree, but, as in all alloys having a ferrous base, the iron dissolves the hardening constituents at a temperature far below its melting point. This, of course, is the basis for the heat-treatment of steels. On the other hand, cobalt, which is the base of the wear-resistant hard-facing alloys, does not dissolve the other constituents until the metal almost reaches its melting point. For this reason, alloys having a cobalt base and which are hard at ordinary temperatures also possess a great amount of red hardness.

Whenever two surfaces rub together, the frictional work done is converted into heat at the point of contact. Temperatures at the very surface are often extremely high. A good example of this phenomenon is the time-worn custom of rubbing sticks together to make fire. Numerous laboratory experiments have substantiated this. One test, in which the ends of an open thermo-couple are held by hand against a rotating steel disk, yields a surface temperature of 1,500° F. — high enough to soften appreciably most iron-base alloys.

Since hard alloys usually wear less rapidly than softer ones, the wear resistance of a metal is undoubtedly some function of its hardness, but the effective hardness in determining wear resistance should be measured by the actual hardness under working conditions. The working temperature of the extreme surfaces of two metals in contact is often extremely high, as evidenced by many experiments. Thus, a metal's resistance to softening and distortion at these elevated temperatures will determine its wear resistance. In other words, red hardness, rather than cold hardness, is a yardstick of wear resistance. Metals like the cobalt-chromium-tungsten alloys, which possess the desirable property of red-hardness, are continually coming into greater demand wherever abrasion resistance is necessary.

"Special metals for special uses" is more and more becoming the slogan of our metallurgists. That this slogan is also being taken up by engineers is evidenced by their appreciation of the value of the metallurgical research and development work. This appreciation is demonstrated concretely by the increasing usage of special materials throughout industry. The hard-facing process for preventing excessive wear of machine parts is an excellent example of a metallurgical step forward which has been almost universally accepted by engineers.

Hard-facing and hard-setting oil well drilling bits with diamond substitutes has become standard practice all over the world

Ore for Giant Aerial Torpedoes and bombs is mined with Allis-Chalmers equipment.

One of many new Allis-Chalmers ste turbines which are helping to power t greatest war production effort in histo

Bundles for Berlin... Power for Pittsburgh!

ALLIS-CHALMERS EQUIPMENT HELPS MAKE BOTH

"A. HITLER, BERLIN, GERMANY" That's what we'd like to label just one of the thousands of tons of ore which Allis-Chalmers equipment is helping to mine and turn into aerial torpedoes and bombs!

And that turbine above is another Allis-Chalmers product that will soon be turning out trouble for Hitler—supplying power to great war plants—helping to make America's soldiers the best equipped in the world.

These are just two examples of how thou-

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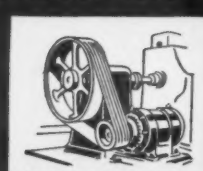
ALLIS-CHA

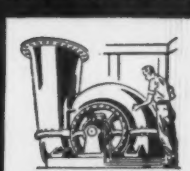
OFFERS EVERY MANUFACTURER EQUIPMENT AND ENGINEERING CO OPER

ELECTRICAL EQUIPMENT

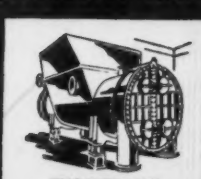
STEAM AND HYDRAULIC TURBINES



MOTORS & TEXROPE V-BELT DRIVES

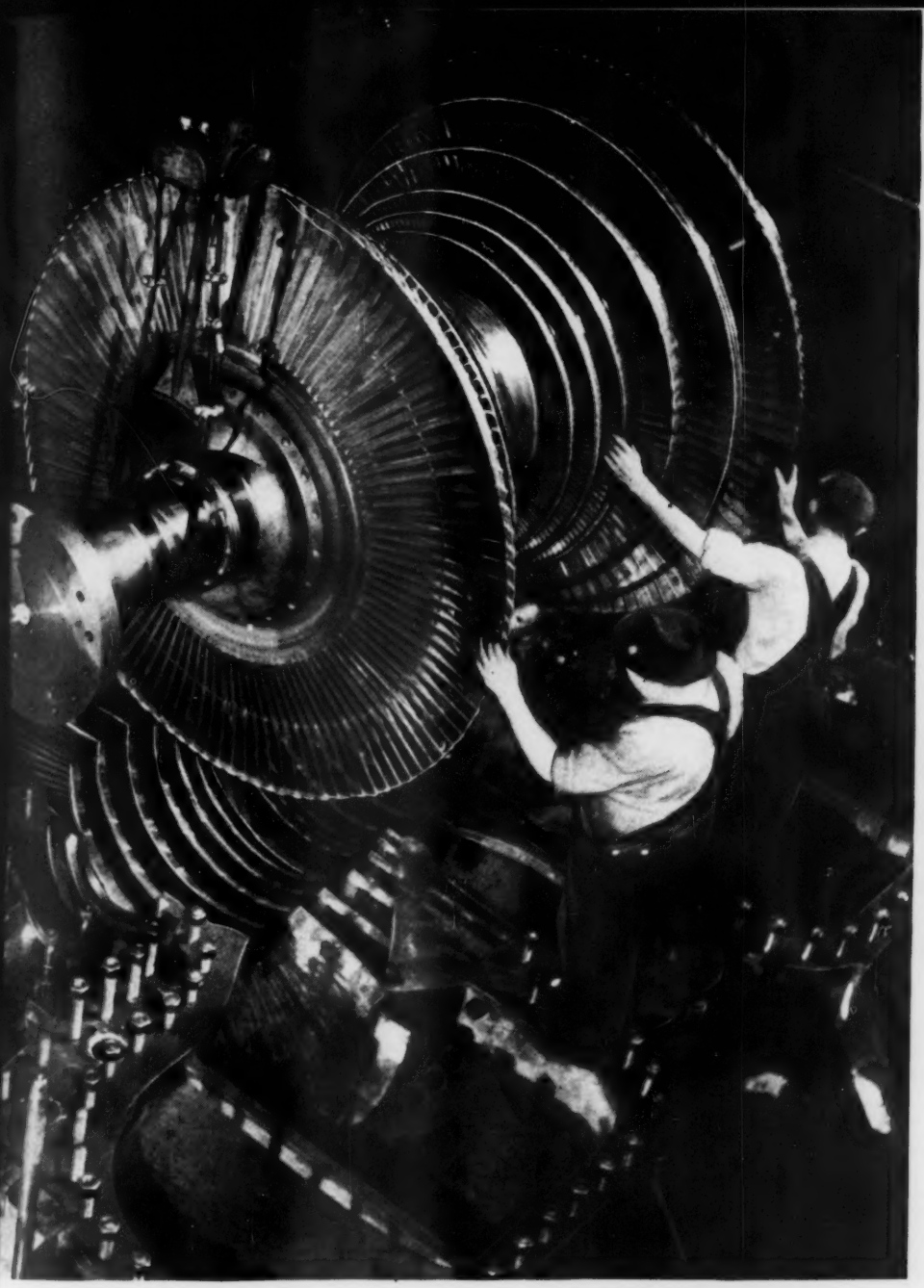


BLOWERS AND COMPRESSORS



ENGINES AND CONDENSERS

CENTRIFUGAL PUMPS

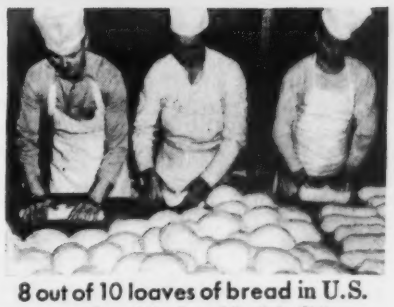


sands of Allis-Chalmers people are fighting the Axis—are *working for Victory!*

Over 1,600 Allis-Chalmers products are working in the Battle of Production. And our Cooperative Engineering service is helping makers *produce more*—not just with new machines, but with *machines now on hand!*

This production experience will be of added value when the war is over. We work for Victory—we plan for Peace!

ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.



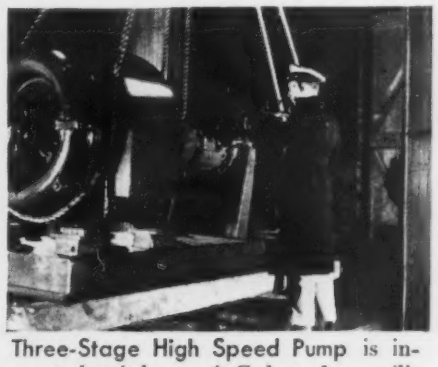
8 out of 10 loaves of bread in U.S. are made with the aid of A-C farm and flour mill equipment.

VICTORY NEWS

Washington, D. C. — Keels for more than 140 "Liberty" ships have been laid and more than 60 ships have been launched from ways which did not even exist before 1941. Original schedules have already been more than doubled.

To set the fastest shipbuilding record in history, mass production principles are used. More than 500 makers are feeding parts to Liberty ways.

From Allis-Chalmers, one of the most important of the contributing firms, comes products ranging from machine-gun cooling pumps to propulsion shafting.



Three-Stage High Speed Pump is inspected as it leaves A-C shops for a military destination. Equipment includes Allis-Chalmers motors and switchgear.

Milwaukee, Wis. — Mosquito boats no longer have to use their motors to recharge their batteries—small Allis-Chalmers rectifier units now do this job.

This unit is the newest means of obtaining nominal d.c. current from existing a.c. power lines. It eliminates need for keeping ships motors running for battery charging on shore. It also aids coast defense by helping to supply power for shore searchlights.

Industrial plants are also using the new unit to supply small amounts of d.c. for individual drives on planers and other machines, in laboratories for testing purposes, and in tool rooms.

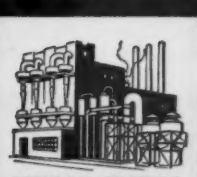
FOR VICTORY
Buy United States War Bonds

HALMERS

WE WORK FOR VICTORY — WE PLAN FOR PEACE

G CO OPERATION TO HELP INCREASE PRODUCTION IN THESE FIELDS...

FLOUR AND SAW MILL EQUIPMENT



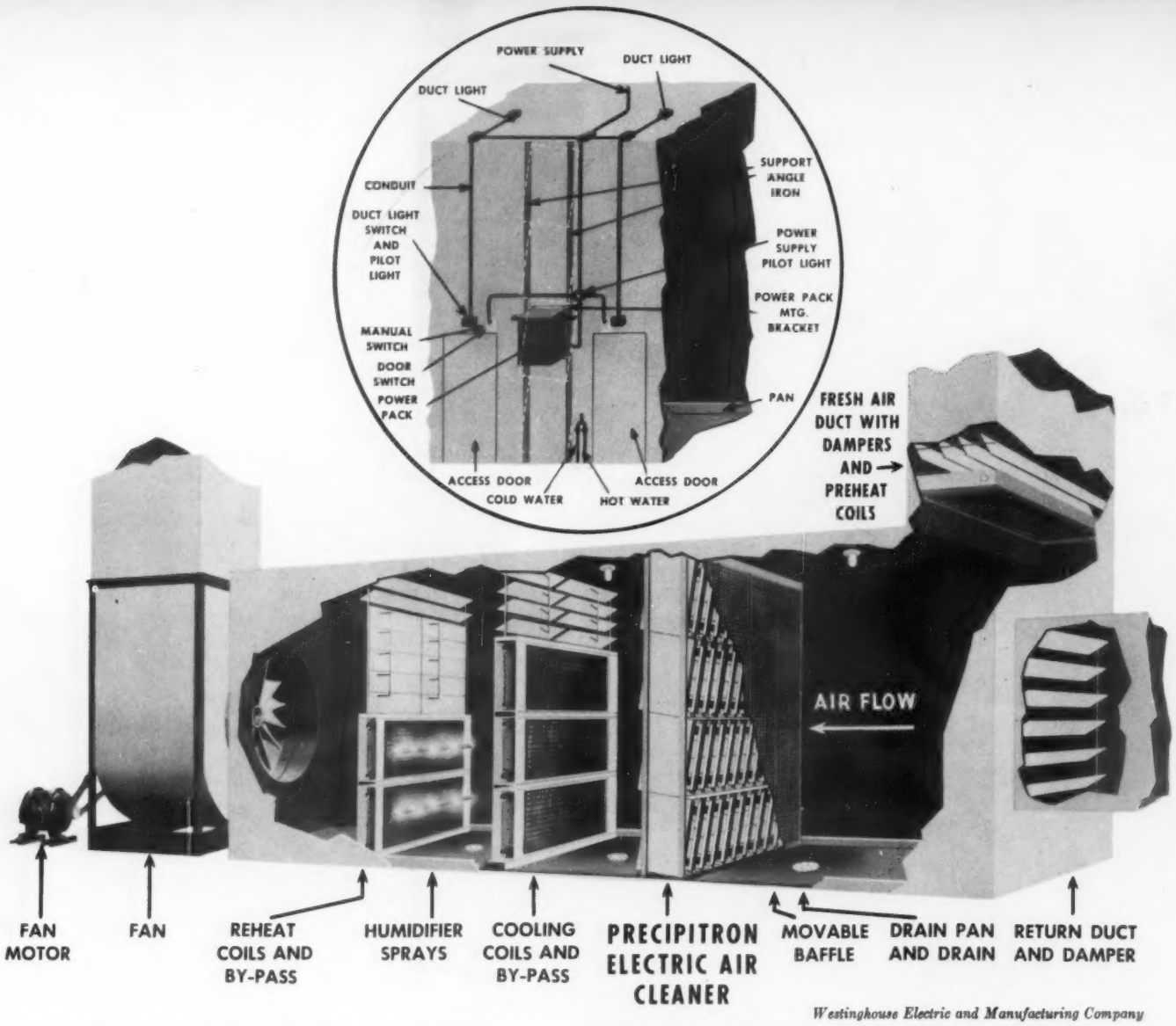
CHEMICAL PROCESS EQUIPMENT

CRUSHING, CEMENT & MINING MACHINERY

BOILER FEED WATER SERVICE

POWER FARMING MACHINERY

INDUSTRIAL TRACTORS & ROAD MACHINERY



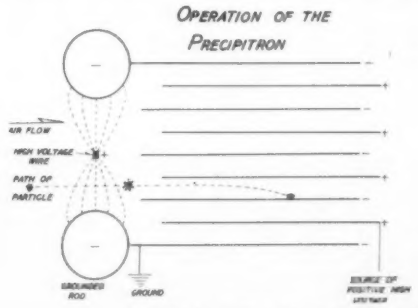
Westinghouse Electric and Manufacturing Company

Cutaway view of typical air duct showing Precipitron as the cleaning component of an air-conditioning system

PRECIPITRON

BASIC PRINCIPLE OF ELECTROSTATICS NOW MAKES AIR CLEANER THAN EVER

By CLYDE C. SNYDER, JR., '44



Westinghouse Electric and Manufacturing Company

A foreign particle passing through the field between the wire and rod receives a positive surface charge. The charged particle is carried into the plate assembly and is drawn out of the air stream to a pole of opposite polarity.

DUST is everywhere. It has been discovered in many places least suspected, such as over the ocean and at altitudes of 10,000 feet. That which is over bodies of water is composed largely of salt; that at many feet above the earth has been known to contain even hay fever pollens. But the dust most serious to man's activities and health is that which is produced extensively in industrial areas, and which, fortunately, because of the nature of its source, can be almost completely eliminated.

Dust particles vary widely in size. While a few of them are big enough to see, by far the greater number are below the range of visibility, this range stopping when the particles are about ten microns in diameter. Because of the optical limits of even the best microscopes (about .001 micron, one micron being approximately one twenty-five thousandth of an inch), the smallest particles can not be seen. It is this wide range of size, as shown in the dust spectrum table, that makes practical air cleaning difficult, the very small particles (under 0.3 micron) never settling out by gravity alone, merely remaining suspended in the atmosphere except when removed by rain or air currents. It is interesting to note that many of these smaller particles serve the useful purpose of acting as nuclei for raindrops.

It is a fundamental principle of static electricity that if two dust particles are oppositely charged, they will be attracted to each other. It is on this principle that the process of trapping dust electrically depends.

It was first successfully applied by Sir Oliver Lodge in 1884 to a lead smelter. In 1906 Dr. Cottrell brought out one of the first practical precipitators, and it is the principle of this machine upon which the Precipitron, developed by the Westinghouse Electric and Manufacturing Company, operates.

The principle on which both the Cottrell precipitator and the Precipitron function is roughly this: air which contains foreign matter is passed through a system of wires and rods (or metal plates), a potential difference being maintained between these electrodes. Any particle which passes through the ensuing electric field picks up a positive or negative charge, depending on how the wires and rods are charged. The particle is then attracted to either the plates or rods helping to produce the electrostatic field, or to plates which are outside of the field but in the path of the air stream.

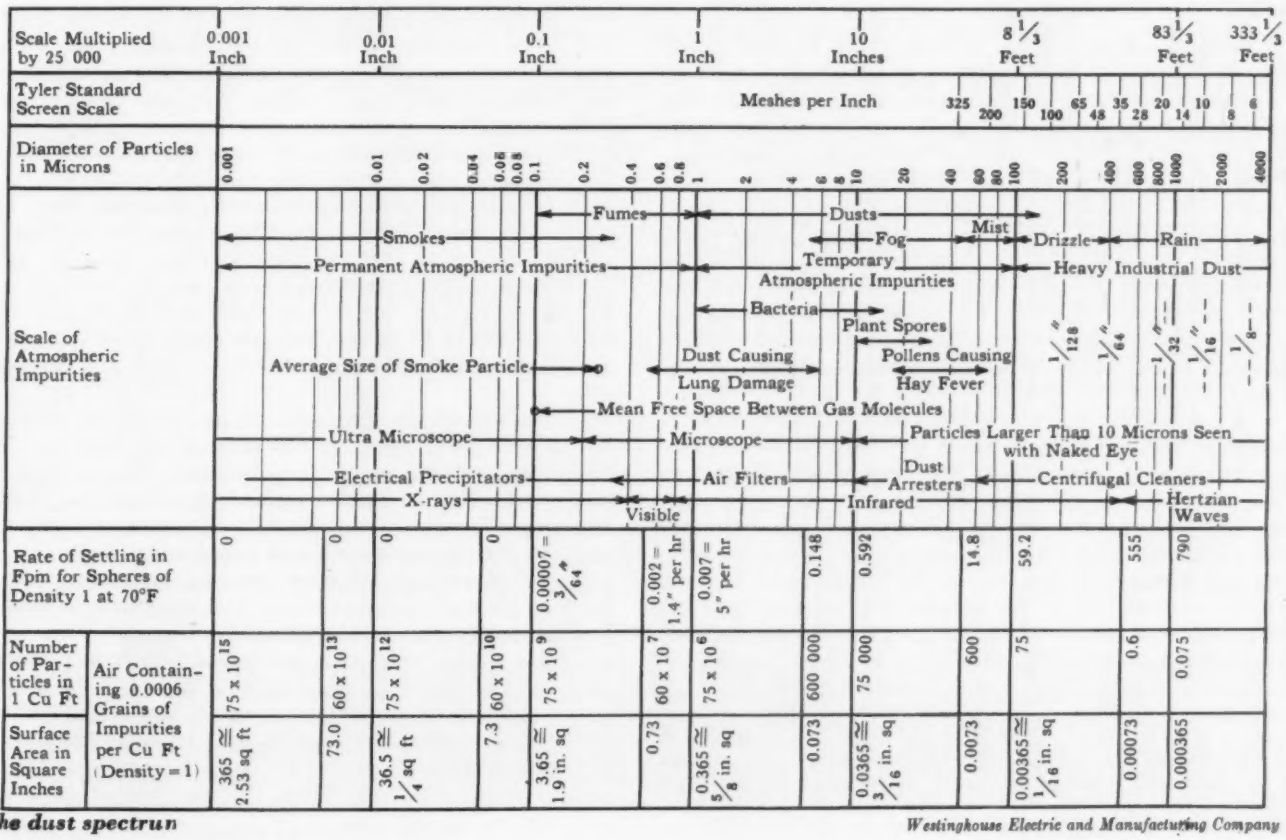
In the Cottrell precipitator a heavy wire is negatively charged and runs down between metal plates which are positively charged, the latter strongly attracting and holding any dust particle that has become negatively charged by the field. The Precipitron differs from this arrangement in that its wire is made positive instead of negative and is of much smaller diameter than that in the Cottrell machine. The rods are simply grounded. The positive charge on the wire reduces considerably the production of dangerous ozone, while the smaller size permits a much lower voltage to be used. It is largely because of these two facts that the Precipitron is well suited for installation in ventilating systems, whereas the Cottrell precipitator is better adapted to industrial cleaning such as the smoke from the chimneys of factories. Because of the lower voltages permissible, the Precipitron also has the advantages of less operating power used and of being a more compact unit. In fact, in 1931 when Mr. G. W. Penney of Westinghouse reduced the necessary operating potential from 30,000–100,000 to about 12,000 volts, installation space was cut to approximately 1/50 that required by the Cottrell system. Smaller wires and consequent smaller ionizing space can be utilized in ventilating systems because the amount of dust to be precipitated is much less than in industrial situations, the diminutive wires in turn lowering the necessary voltage because the charge is concentrated on a smaller surface.

The Precipitron also differs from the Cottrell cleaner in regard to the separation of the ionization and collection functions. In the Precipitron the two processes are done separately, resulting in a considerable reduction in the space occupied and in the cost of the unit. When the voltage requirements are noted for the two plans, it is easily seen that this separation is a very logical one, because the potential difference needed for ionization is 12,000 volts, whereas that necessary for collection is only about 5,000 volts to ground. If the Precipitron were made so as to perform both of these functions in a single field, where the necessary voltage would of course be 12,000 volts, the combined charging and collection cell would be greatly increased in size because higher potentials require greater separation. Also of interest is the fact that the charging of the particles is accomplished more successfully if the electric field is non-uniform, whereas collection is facilitated by a field which is definitely uniform.

In the units where charging and collecting are separated, the dust particles are drawn through the charging field caused by the high voltage wire and grounded rod and then go to the collection field produced by parallel plates charged alternately positive and negative. Thus the positively charged particle, as it passes down between any two plates, is attracted by one and repelled by the other, the result being that its path is soon deviated and the particle is trapped.

Electrostatic air cleaners (*Continued on page 124*)

THE DUST SPECTRUM


Scale Multiplied by 25 000
0.001 Inch
0.01 Inch
0.1 Inch
1 Inch
10 Inches
8 1/3 Feet
83 1/3 Feet
333 1/3 Feet
Tyler Standard Screen Scale
Meshes per Inch
325 200 150 100 65 48 35 28 20 14 10 8 6
Diameter of Particles in Microns
0.001 0.01 0.02 0.04 0.06 0.08 0.1 0.2 0.4 0.6 0.8 1 2 4 6 8 10 20 40 60 80 100 200 400 600 800 1000 2000 4000
Scale of Atmospheric Impurities
Fumes
Dusts
Smokes
Fog
Mist
Drizzle
Rain
Permanent Atmospheric Impurities
Temporary Atmospheric Impurities
Heavy Industrial Dust
Bacteria
Plant Spores
Average Size of Smoke Particle
Dust Causing Lung Damage
Pollens Causing Hay Fever
1/128" 1/64" 1/32" 1/16" 1/8"
Mean Free Space Between Gas Molecules
Ultra Microscope
Microscope
Particles Larger Than 10 Microns Seen with Naked Eye
Electrical Precipitators
Air Filters
Dust Arresters
Centrifugal Cleaners
X-rays
Visible
Infrared
Hertzian Waves
Rate of Settling in Fpm for Spheres of Density 1 at 70°F
0 0 0 0 0.00007 = 3/4" per 64 0.002 = 1.4" per hr 0.007 = 5" per hr 0.148 0.592 14.8 59.2 555 790
Number of Particles in 1 Cu Ft
Air Containing 0.0006 Grains of Impurities per Cu Ft (Density = 1)
75 x 10^15 60 x 10^13 75 x 10^12 60 x 10^10 75 x 10^9 60 x 10^7 75 x 10^6 600 000 75 000 600 75 0.6 0.075
Surface Area in Square Inches
365 ≅ 2.53 sq ft 73.0 36.5 ≅ 1/4 sq ft 7.3 3.65 ≅ 1.9 in. sq 0.73 0.365 ≅ 5/8 in. sq 0.073 0.0365 ≅ 3/16 in. sq 0.0073 0.00365 ≅ 1/16 in. sq 0.00073 0.000365

The dust spectrun

Westinghouse Electric and Manufacturing Company

THE TECH ENGINEERING NEWS

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FRANKLY SPEAKING . .

THIS IS OUR JOB

It has been the policy of THE TECH ENGINEERING NEWS during the twenty-three years of its existence to present accounts of the latest advances in science and engineering which would be interesting and instructive to the technical student and man in industry. Each succeeding staff has upheld this policy and attempted to publish a magazine which would be of the greatest possible value to the readers. This year, however, we are publishing for a school geared to an all-out war effort, and we must obtain much of our material from industries and scientific organizations whose activity has been greatly altered by war production and research. How does the present national situation effect the T. E. N.?

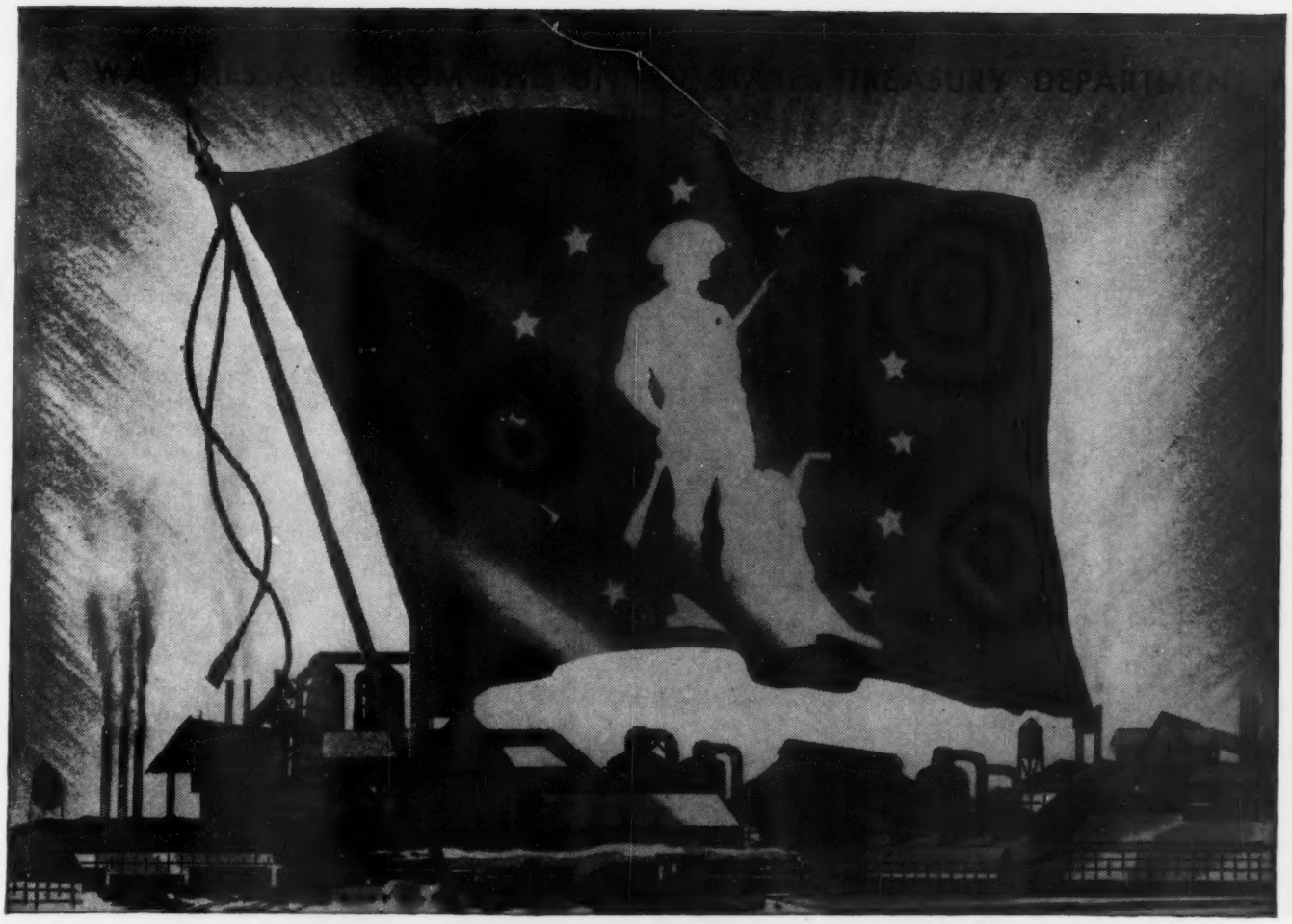
We feel that there is a definite need for technical journals and that their value in wartime is actually greater than in peacetime. In a war in which production methods and scientific research play so vital a part, the general interest in technical topics should, and does, increase. The T. E. N. can help those who wish to keep abreast of activity in the laboratories and on the production lines of the nation. One must remember, however, that much of this work is of such a nature that its detailed description would be of value to the enemy, and accordingly the magazine will continue to use extreme discretion in the selection of articles. If certain subjects, even though they may have received wide publicity in other publications, are apparently ignored, it is probable that complete discussions of the subjects would be dangerous.

This necessary secrecy, together with the greatly increased demands of a wartime industry upon the time of industrial leaders, will probably somewhat decrease the proportion of articles by persons outside the Institute. Yet this may prove to be advantageous, for a larger number of articles by students and members of the Institute Staff will increase its value as a school publication.

We hope to run more articles on the Institute itself, describing research projects, student activities, the work of the different departments, and the like. Of particular value would be discussions by different authorities upon the position of the scientific and engineering student in the present society, and a series of descriptive articles on the various branches of the Army and Navy. In this way we can help the student decide what action he should take to best aid the war effort.

Even though the size of the magazine may be limited by material shortages, we can still attempt to increase the amount of subject matter presented. We can include a larger number of shorter, more concise articles. Many topics can be discussed in brief editorials, and greater use can be made of news briefs and digest articles in which interesting subjects are presented in short reviews by staff members or in condensations of longer articles from other publications.

Thus we feel that it is our job to continue publication of THE TECH ENGINEERING NEWS with a policy only modified to the extent that we can be of greater service to those already holding important positions in the war effort and to the students who are preparing for the duties which they feel will best aid the country.



Next to the Stars and Stripes . . .

AS PROUD A FLAG AS INDUSTRY CAN FLY

Signifying 90 Percent or More Employee Participation in the Pay-Roll Savings Plan

IT doesn't go into the smoke of battle, but wherever you see this flag you know that it spells Victory for our boys on the fighting fronts. To everyone, it means that the firm which flies it has attained 90 percent or more employee participation in the Pay-Roll Savings Plan . . . that their employees are turning a part of their earnings into tanks and planes and guns *regularly,* every pay day, through the systematic purchase of U. S. War Bonds.

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TRAFFIC GOES UNDER

(*Continued from page 107*)

Tunnel is similarly designed; the Manhattan plaza of this project, where rock is nearer the surface, will be a drained structure, that is, walls are sealed to rock, the space below the invert slab excavated to rock, drained to the sump at the portal by a system of pipes and gallery and backfilled with gravel.

The typical finished interior of the Brooklyn-Battery Tunnel will be almost identical with that of the Queens Midtown Tunnel. There is an interior lining of concrete, a roadway slab constructed of concrete and transverse steel beams, below which is the fresh air duct for ventilation, and a reinforced concrete ceiling, above which is the exhaust air duct. Walls and ceiling are finished in tile. A raised walk with an enameled pipe railing is provided to the left of the direction of traffic for tunnel police, maintenance and emergency use. The roadway is paved with brick and has a minimum width of 21 feet between curbs; minimum headroom is 13 feet six inches. It may be noted that the roadway is capable of safely supporting mobile military equipment up to 60-ton tanks.

Lighting in the Queens Midtown Tunnel is efficiently and effectively provided by incandescent lamps installed in light boxes spaced at intervals in each wall just below the tunnel ceiling. Intensive lighting at the entrance portals provides a gradual change from daylight to tunnel illumination, eliminating the blinding effects experienced by motorists on entering other vehicular tunnels. In the Brooklyn-Battery Tunnel lighting will be by fluorescent tubular lamps, which will provide an improvement in quality, continuity and flexibility of intensity, with a substantial saving in operating costs.

Grades in the tunnels are kept approximately within the same maximum limitations: 3.5 per cent up-grade and 4.0 per cent down.

Extensive investigations in connection with ventilation for the Holland Tunnel led to the adoption of the ventilation system successfully employed on that project and on most of the subsequently constructed vehicular tunnel projects. This is the transverse system in which fresh air is introduced to the driveway area through flues which are located at intervals along each side of the roadway, with openings just above curb level and connecting to the fresh air duct under the roadway slab, which carries the fresh air supply from fans in the ventilation buildings. Vitiated air is drawn from the driveway area through ports spaced at intervals in the ceiling over the roadway, and thence into the exhaust air duct above the ceiling through which it is carried to the exhaust fans and discharged through the evasé stacks at the buildings. Sufficient ventilation is provided to keep the carbon monoxide content of the air in the tunnel below 2.5 parts in 10,000.

The ventilation fans and motors are, in general, housed in buildings which are of the power house type of steel frame and fireproof construction and are designed to conform with and often to improve the appearance of their surroundings.

Two ventilation buildings, one in Queens and one in Manhattan, are used for the Queens Midtown Tunnel, which is an average length of 6,343 feet between portals.

Three points of ventilation are necessary for the Brooklyn-Battery Tunnel, which is 9,117 feet between portals or over 600 feet longer than the Holland Tunnel. The usual type of building providing for blower and exhaust fans is to be located in Brooklyn, and similar provision will be made for (*Continued on page 118*)

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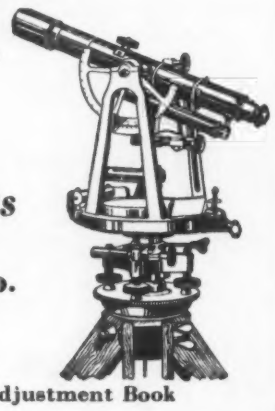

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TRAFFIC GOES UNDER

(*Continued from page 116*)

ventilation at a location just off the northeasterly end of Governors Island. This building will connect to the tunnel by means of a deep ventilation shaft to be sunk by pneumatic caisson to bed rock, and through the rock to subgrade at a depth of 139 feet below mean high water. Tunnel roadway elevation is 115 feet below mean high water at this point. Because of its prominent location in New York Harbor, the appearance of the Governors Island building has been given more than the usual consideration.

In Manhattan, a building housing only the blower equipment will be constructed at the portal which is located north of Battery Place. The exhaust building and equipment will be located below ground in Battery Park, and the exhaust air discharged through some form of stacks or pylons, located in the park, architecturally treated and laid out to fit the scheme of the park plan. This departure from the usual method was considered advisable because of objections on the part of building operators who considered that the discharge of exhaust air from the tunnel near the roof-top level of their buildings might endanger the health of their tenants. Actually the present practice in ventilation would produce an effluent containing, at a distance of 120 feet from the point of discharge, a concentration of carbon monoxide definitely harmless and amounting to only one-tenth the concentration of this gas in some of our city streets at peak hours of traffic as determined by the United States Bureau of Mines.

The Queens Midtown Tunnel was constructed under a closely coördinated program comprising more than thirty principal contracts, the largest of which was that for the river tunnels which was let to the Walsh Construction Company at a final cost of $22,133,304.32, not including $3,333,587.58 for cast iron tunnel lining and $191,781.14 for nuts, bolts and washers for the erection of the lining, which were furnished under other contracts.

The river tunnels were driven under compressed air which reached a maximum pressure of 37½ pounds per square inch, using four tunnel shields, two progressing westerly from a shaft in Queens and two easterly from shafts in Manhattan, to a junction in the rock reef near the middle of the East River. The shafts were about 4,000 feet apart. The shields were each 31 feet eight inches in outside diameter with a length of 15 feet 10 inches and a hood above springing line projecting an additional two feet 10 inches. The middle section of each shield was divided into 13 working pockets by horizontal and vertical struts, which together with a ring girder reinforced the three-inch thick steel skin of the shield at that section. The cutting edge and hood were made up of ribbed steel castings, and the unreinforced skin section of the shield extended back of the midsection to form the tail, in the protection of which successive rings of cast iron lining were erected as the face was excavated and the shield shoved forward a ring length at a time. The shields were each equipped with 28—10-inch hydraulic shoving jacks which reacted against the completed cast iron tunnel lining using a hydraulic pressure of 5,000 pounds per square inch, and there were 28 sliding platform and face jacks to facilitate the excavation and support of the face. A hydraulic erector arm, attached to the axis of the shield, was used to erect the cast iron lining segments, which were bolted together by hand, using two to three men on a five-foot ratchet wrench for this purpose. A minimum bolt stress of 25,000 pounds per square inch was specified.

(*Continued on page 120*)

The giant "Pencil Sharpener" that grinds out projectiles!

Imagine a machine that grinds out 37-mm projectiles almost as easily as you'd sharpen a pencil! Getting the precision of form and finish necessary for accurate shooting was once a much slower procedure. But that was before Carborundum helped develop the wheels for centerless grinding of projectiles. Now the process is simple. First, slice off a piece of cold rolled steel bar stock to exact length with an abrasive cutting off wheel, turn the nose to approximate profile and heat treat to required hardness. Then feed this piece between the specially shaped wheels of a centerless grinder...and...out pops a projectile!

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TRAFFIC GOES UNDER

(*Continued from page 118*)

All material excavated was loaded into muck cars with mechanical mucking machines which had access to the face through the large bottom pocket provided at the bottom of each shield. Storage battery locomotives were used for haulage, and all muck disposed of through the shafts which were equipped with cages, headframes and muck hoppers, loading the trucks used for final disposal from the hoppers.

Passage of men, muck and materials to and from the compressed air sections of the tunnels was through locks of the usual type installed in the 12-foot concrete tunnel bulkheads. Emergency locks, emergency runways and safety screens were provided to facilitate escape from the heading in case of flooding. Hours of work, times for decompression and medical supervision of employees engaged in work in compressed air were strictly in accordance with the regulations of the New York State Industrial Code.

Two plants, one on each side of the river, were equipped with the necessary air compressors and hydraulic and electric equipment to supply the headings. The low pressure air equipment of each plant, supplemented by an allowed 80 per cent of the high pressure air capacity, was capable of supplying over 45,000 cubic feet of free air per minute at a gage pressure of 50 pounds per square inch. Two 14-inch air lines, one for emergency, delivered low pressure compressed air to each heading.

Preliminary test borings had shown the rock floor along the tunnel lines to vary greatly in both character and elevation, so that the headings would pass many times in and out of earth, earth and rock and rock. The various bed rocks encountered along the tunnel line were Manhattan schist, Inwood limestone, Fordham gneiss, Hell Gate dolomite and Brooklyn injection gneiss. There were zones of disintegrated rock at contact points and low points. The overburden, consisting of porous glacial deposits of sand, gravel and boulders, as well as mud and fill, was not of a character to hold compressed air. These conditions, together with the large diameter of tunnel, larger than ever before attempted in the unfavorable materials of the bed of the East River, indicated to prospective contractors difficulties and risks which were reflected in the excavation prices bid, the let prices per cubic yard being: earth $62.00; rock $52.50; and mixed face $96.00. Normal average progress in these materials proved to be, respectively: 7.4, 3.2 and 3.7 feet per 24 hours. Tunneling was conducted on a 24 hour a day, six days a week schedule.

On the basis of total elapsed time, average progress was 18 feet per week per heading.

The first shield was erected in February 1938 and both tubes "holed through" on November 8, 1939. The success of tunneling was due to careful planning and coöperation on the part of all concerned.

The worst difficulties encountered were on the Manhattan side, where loss of compressed air through porous material at times required the full capacity of the Manhattan plant to maintain adequate pressures in one heading. Air pressures necessarily balancing water pressure near the bottom of the 31-foot diameter tubes created an excess of air pressure over hydrostatic head at the top of the tube amounting to as much as 10 pounds per square inch. In porous material this large excess head intensified the escape of air and required extreme care in excavation. The necessity for "mudding up" the face, packing the space between shield tail and lining with burlap bags, and grouting outside the lining and at the face with volcanic clay, cement and sawdust mixtures to cut down the escape of air resulted in very slow progress in some of the more difficult sections. At one point near the river bulkhead on the Manhattan side, the headings were in open rip-rap and even coal from an overturned barge.

Where the natural cover over the top of the tunnel had not sufficient weight to counteract the unbalanced air pressure at the top of the tubes, it was necessary to deposit a clay blanket of sufficient thickness to prevent the compressed air from blowing out the river bed and causing a disastrous flooding of the tunnel. 400,000 cubic yards of clay, deposited in the west and east channels of the East River, were used for this purpose. This clay blanket had a maximum width of 480 feet and a maximum depth of 45 feet above original river bottom. It was all removed except for a length of somewhat over a hundred feet over each tube in the west channel where the tops of the (*Continued on page 122*)

Manhattan Plazas; Queens Midtown Tunnel *New York City Tunnel Authority*

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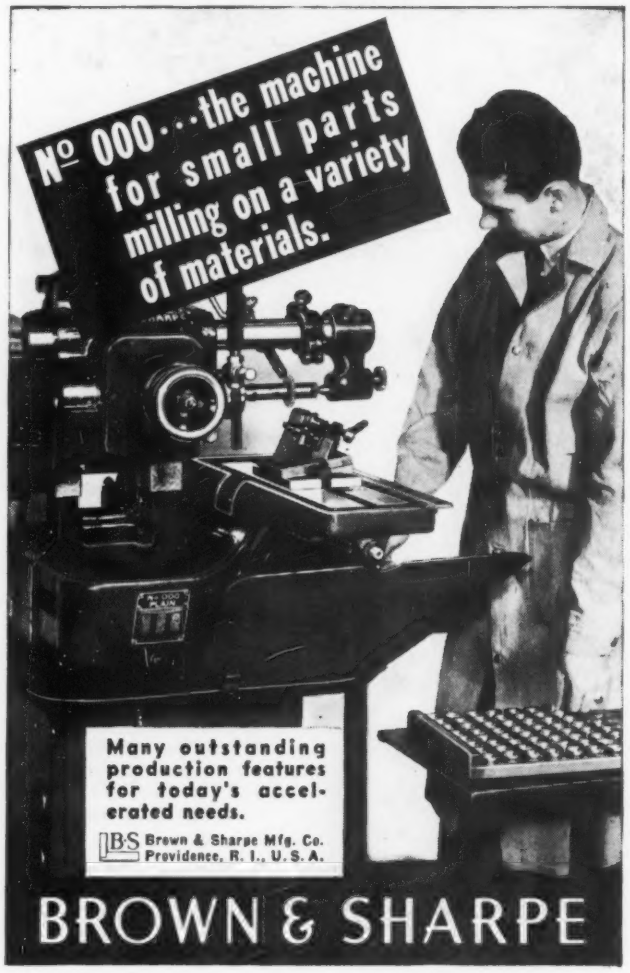
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TRAFFIC GOES UNDER

(*Continued from page 120*)

tubes were driven as much as eight feet above the original river bottom. Here, sufficient clay was left, protected with rip-rap, to form a permanent cover over the tubes, a minimum of 13 feet thick.

In spite of the difficulties encountered in tunneling under the East River, the Queens Midtown Tunnel was completed and opened to traffic well ahead of schedule.

The construction schedule for the Brooklyn-Battery Tunnel originally was set up in 27 major contracts with a project completion date in the fall of 1944. This schedule has proved impossible on account of the scarcity of certain necessary construction materials in these times of war. The work now in progress is only that for which materials were already at hand when our country entered the war, most of the work being excavation not requiring any critical materials.

Two contracts are in progress, consisting of two rock headings being driven south from Manhattan by the Mason & Hanger Co., Inc., contractors, and two shield and compressed air headings progressing north from Brooklyn under contract with the George H. Flinn Corporation.

When test borings for the Brooklyn-Battery Tunnel were completed, it was shown that by lowering the profile, which had been determined from preliminary data, about 15 feet at the maximum point, a much greater length of rock tunnel construction was possible, and a corresponding amount of compressed air tunneling eliminated. The depth of roadway as adopted is a maximum of 115 feet below mean high water or 20 feet greater than the maximum depth of the Queens Midtown Tunnel roadway.

The borings show the rock to be entirely Manhattan schist and the rock floor to be comparatively regular in elevation. About 2,900 feet of the crossing requires shields and compressed air, 2,800 feet of this from Brooklyn to the rock reef at Governors Island and about 100 feet being necessary at a dip in the rock line occurring in the vicinity of the Battery Park bulkhead. 4,900 feet of the crossing will be rock tunneling.

Overburden consists generally of stratified silt and clay under Buttermilk Channel and stratified sand and gravel, with some clay and boulders, under Hamilton Avenue.

In general, the conditions in both rock and earth are much more favorable than those encountered in driving the Queens Midtown Tunnel.

The same methods and kinds of equipment are being used in shield tunneling that were used in the Queens Midtown Tunnel, with one interesting exception. In leaving the construction shaft in Brooklyn, the shields had only 10 feet of cover, insufficient to counterweight the unbalanced head of compressed air necessary to provide a dry face under conditions of normal ground water elevation. This problem was solved by sinking a dewatering well, 11 feet in inside diameter, from the bottom of which horizontal strainer pipes were driven in a radiating pattern to cover the tunnel area from the construction shafts to 400 feet north of the shafts. The strainer pipes were driven at an elevation which was 10 feet below subgrade of tubes at the northerly point, and pumping by two 2,200 gallons per minute capacity pumps installed at the well has lowered ground water sufficiently to permit driving the tubes in free air to over 400 feet north of shafts where, due to the down grade, the cover is 25 feet, adequate for tunneling with compressed air.

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(*Continued from page 113*)

have quite a few advantages over mechanical filters. But before we go into this, let us look more closely at the different types of mechanical air cleaners that are in use today. Practically all of these can be placed in one of the four following groups: impingement, straining, inertia, and washing. The impingement type of filter consists of glass fiber, steel wool, animal hair, cellulose batting and vegetable fiber as a medium. The filler is coated with some viscous material which helps retain the dust. Most of these filters are meant to be thrown away after becoming clogged up; however, some of them are capable of being washed and used again. In the straining type the dust particles are strained out by a closely woven fabric, this being destroyed after use. The inertia type makes use of the force encountered by a particle in making a sharp turn. In some of this type the air is forced to change direction very sharply, the particles going off at a tangent and adhering to vanes which are later cleaned by washing. The air washers are usually used in connection with air conditioning systems where they help to control temperature and humidity as well as purify the air. This method is not too effective for small particles, and also has the disadvantage of being quite bulky as pumps and other auxiliary equipment are needed.

The greatest advantage which the Precipitron has over the mechanical filters is that it has the widest range with respect to the size of particles which can be removed. It will trap all those down to the smallest which can be seen with a microscope (0.001 micron), whereas quite often in the mechanical filters particles up to two microns in size are passed. The reason that this is so is because in the filter type of cleaner the size of particle which will be passed or retained is determined by the size of the minute openings permissible between the fibers of the filter medium consistent with a flow of air through the machine, or by the mass of the particle in the inertia type; in the Precipitron the particle is held by the electrostatic forces between it and the retaining plates. Although this force does vary some because the charge carried by the particle is proportional to its size, it is still great enough to trap particles far too small to be retained by even the finest filter, or be thrown against the vanes by the sharpest curves in the inertia type. The electrostatic air cleaner also offers practically no resistance to the air flow, and requires no replaceable parts outside of tubes in the power pack.

In order to test the efficiency of the Precipitron it was necessary to devise a test that would demonstrate how much dirt that was in the air was being removed. Accordingly, the Westinghouse engineers designed what they named the Blackness Test, wherein a stream of air is drawn through a cloth placed over an intake. Samples of the dirt deposits are taken ahead of and behind the Precipitron, and since this air flow can be accurately measured and adjusted, the efficiency of the cleaner can be determined by comparing the times required in order to obtain spots of equal darkness. According to this test, the cleaner's efficiency is about 85 per cent at 750 cubic feet per minute, and about 90 per cent at 600 cubic feet per minute per 36 inch cell. Even a more refined version of the Blackness Test by the National Bureau of Standards gives an efficiency of over 90 per cent. That of the average mechanical filter is about 25 per cent.

The power supplied to the electric field producing wires, rods and plates is high voltage d.c. which is drawn from a rectifier. The high voltage is obtained by using a step-up transformer while the current is still a.c.

In application the Precipitron is much used by retail establishments because of the great savings brought about by eliminating a large part of the frequent redecorating and by doing away with the huge losses always present when goods are spoiled by dirt. In the optical industry even the smallest amount of any kind of dust may impair the polished surfaces of lenses or prisms, or what is just as serious, a dust particle may be trapped inside of a molded piece, thereby hindering its optical correctness. In fine machine work dust is exceedingly unwelcome. This is particularly true in the aircraft industry where, with their tolerances of 1/10,000 of an inch or less, a dust film of the thickness of a few wavelengths of light may mar the accuracy of the product.

Looking toward the future, air cleaned electrostatically will certainly be present in many of the homes. It is quite possible that air conditioners may sometime include an electrostatic air cleaner as an integral part of the unit. Furnaces in private homes is another very logical place that we might expect to find dirt being removed at the source by this method. However, all of these uses must certainly wait until the present war passes before they can even start to be realities.

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G-E Campus News

COLLECTOR

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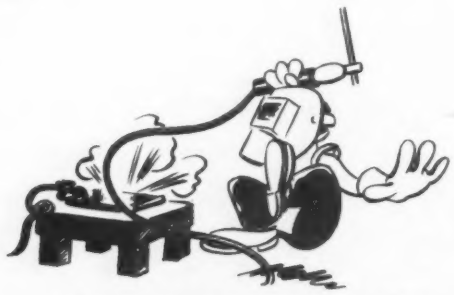

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SH-H-H-H-H-H!

THE one announcer in the country who can give weather forecasts over the air is a mechanical man who broadcasts from a point 12 miles up in the stratosphere, where next week's weather is in the making.

This mechanical investigator, whose heart is an electron tube, works for the U. S. Weather Bureau. He weighs only a couple of pounds and looks like a large box camera.

As a small balloon takes him up, the robot broadcasts the atmospheric conditions he finds. Tuned in with a ground receiver, the radio signals tell the temperature, wind velocity, etc. The balloon bursts at the low pressure limit (about 60,000 feet above ground), and a parachute brings the radio sonde, as it is called, down to earth.

The mechanical weatherman carries a calling card with his return address on it in case he gets lost on the way back.

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